Hydrogeologic Assessment at the Park Center Well Pursuant to an Application for Change of Designation from Tributary to Non-tributary Status

Prepared for:
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U.S. Bureau of Land Management

by

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BUREAU OF LAND MANAGEMENT
PARK CENTER WELL
HISTORY OF USE

The Park Center Well was drilled as an exploratory oil and gas well between 1923 and 1927. The well was a failure for oil and gas production, but water was produced under artesian pressure. The well drillers estimated water potential water production at 22,000 barrels per day.

As provided for by law, the Federal government purchased the well casing and conditioned the well for water production in 1934. Records indicate that the well was controlled and has not flowed freely since 1935. The well can produce 781 gallons per minute against a pressure of 143 psi.

In 1937, the Canon Heights Irrigation Company entered into a lease with the United States for use of the water from the well. Water was used to irrigate an estimated 800 acres north of Canon City.

In 1968, the Park Center Water District was formed to provide domestic water to residences in the North Canon City area. The users were largely the same people who had used the water for irrigation. When the domestic district was formed, 130 users were served. By 1991, approximately 788 households were served, and in 1997 there are approximately 1,000 households that use this well as a source of domestic water.

In 1990, the United States was awarded a reserved right on the well for 2.67 cfs. Historical use of the well has been a minor fraction of the Federal reserved right.

In 1991, the existing lease on the well was re-negotiated with Park Center Water District. The lease provides that the purpose of the lease is to provide the water district and its inhabitants the full use of all production from the well as a source of domestic water for their present and future needs.

Based upon records from a totalizing meter at the well head, average annual diversions between 1982 and 1991 were 247 acre feet. In water year 1994, diversions from the well were 353 acre feet, as recorded from the meter. Because the well is presently decreed as tributary, BLM is currently member of the Arkansas River Groundwater Users Association (AGUA). The association assumes that the District consumptively uses 38.5% of the amount diverted annually at wellhead, and that the remainder reaches the Arkansas River system as return flows from the District.

Park Center Well
Hydrogeologic Assessment for Nontributary Designation

Introduction

This report is prepared pursuant to an application to change the designation of the Park Center Well from "tributary ground water" to "nontributary ground water". A designation of "tributary ground water" is not consistent with hydrogeologic conditions at the well, and a change in designation is requested.

Site Description

Location of well:
T. 17 S., R. 70 W., sec. 34, NE¼SW¼SW¼ (Garden Park area)
Fremont County, Colorado
Depth of well: 3,216 ft.
Depth of aquifers: 2675-2738 ft. and 2778-2797 ft. (in basal unit of Fountain Fm.)

The well is located about 4 miles north of Canon city, in an area known as Garden Park. Known as the Mutual Oil and Development Company well drilled during the period April 1923 to August 1927. The total depth of the well is 3,216 ft.; drilling was terminated in the Manitou Limestone. Drilled as an oil test, the well failed to discover economic reserves of oil or gas. Some limited oil shows were found in the Morrison Formation, but an oil or gas reservoir was never developed in this area. Later, the well was converted to a water well because of the copious amounts of good quality water obtained under artesian conditions. The well was flowing 12,000 barrels per day (350 gal/min) when drilled.

The well is currently being used for water supply for the Park Center Water District under leasing arrangements from the Bureau of Land Management. The water rights decree for this well is 2.67 cfs.

Geology

The well is located at the south end of Fourmile Creek Graben, an area of faulted precambrian rocks overlain by sedimentary beds of the Manitou Limestone, Harding Sandstone, Fremont Limestone, Williams Canyon Limestone, Fountain Formation, Ralston Creek Formation, Morrison Formation and Dakota Formation. These deformed sedimentary beds form the Chandler Syncline having its axis about 1¼ mile west of the well site. West of the axis of the Chandler Syncline, the beds are tilted at a much steeper angle, and dip towards the east. This structural feature provides the framework for confined ground water to exist, as indicated by many artesian flowing wells in the area, primarily to the south in the Canon City/Florence Basin. The Park Center well is situated in the extreme southern end of the Fourmile Creek graben adjacent to Fourmile Creek (figure 1). The surface formation upon which the well is located is the lower portion of the Morrison formation. Based on outcrop information (measured sections) and available well data, the subsurface stratigraphy at this site includes sedimentary strata from the Manitou Limestone (Lower Ordovician age) up to and including the basal section of the Morrison Formation (Upper Jurassic age). The subsurface stratigraphic sequence at the well is substantiated by the geologic log prepared for the Mutual Oil and Development Co. #1 well (Park Center well)

when it was drilled in 1925 (figure 2). The interpretation identified on this log has been modified based on subsequent interpretations and changes in stratigraphic nomenclature. The casing and completion record for the well is shown in figure 3.

The stratigraphic sequence at the well includes sedimentary beds about three thousand feet thick that overlie the precambrian basement complex.

Stratigraphic Column

Mutual Oil & Development Company Well #1
T. 17 S., R.70 W.,6th PM Sec. 34 SW¼SW¼

Formation	Log Top	Elevation
Morrison	Surface	+5630 feet
Ralston Creek	150 feet	+5480 feet
Fountain	350 feet	+5280 feet
Williams Canyon	2800 feet	+2830 feet
Fremont Limestone	2842 feet	+2788 feet
Harding Sandstone	2930 feet	+2700 feet
Manitou Limestone	3195 feet	+2435 feet

The stratigraphy includes the following formations from the producing formation upward (oldest to youngest):

Pennsylvanian/Permian Age

Fountain Formation - The Fountain Formation consists of a thick, massive, highly cross-bedded, coarse red arkose and boulder conglomerate in the lower third of the unit. The upper two thirds being primarily a red sandy shale, with medium- to coarse grained arkoses and a few thin, nodular, fresh water limestones. The over-all red color of the Fountain is due to coatings of hematite and red clay around the sand grains, and also to the abundance of pink feldspars. The Fountain reaches an approximate thickness of 2000 feet in the northern part of the Embayment and thins gradually in a southward direction, and is not present southwest of Canon City. The Fountain lies unconformably on the Williams Canyon and is disconformable with younger strata. The producing zone is at about 2650 ft. to 2800 ft. depth, at the contact with the underlying Williams Canyon Formation.

Jurassic Age

Ralston Creek Formation - This formation is represented by a massive gypsum section interbedded with thin, green siltstones or shales and a thin basal conglomerate. The gypsum section thins rapidly to the west with an accompanying facies change to an interbedded red shale, orange siltstone and gray to pink, reworked arkose. The thickness

in the northern portion of the embayment ranges from 35 to 150 feet and the unit disconformably underlies the Morrison.

Morrison Formation - This formation commonly contains massively bedded lenticular sandstones, light gray limestones, light green marls and varicolored sand shales. Lateral changes are extreme in the Morrison and few beds can be traced more than 200 yards along the outcrop. Lenses and channel fills are common. The thickness ranges from 100 to a maximum of 480 feet in the Garden Park area. The Morrison disconformably underlies the Lytle Sandstone member of the Purgatoire Formation.

Structural Setting

The Park Center Well is within the Canon City embayment which is a structural re-entrant located in the extreme southwestern corner of the Denver Basin. The embayment is bounded on the west and southwest by the Wet Mountains, on the north and northeast by the Front Range and on the east by the Brush Hollow horst (southern plunge of the Front Range). The embayment was developed during the Paleozoic age with recurrent movement during the Laramide along similar trends. High angle reverse faults and thrusts now characterize the margins of the embayment, especially in the northern portion, Fourmile Creek graben. The southern and western portion of the embayment is dominated by the elongated northwest-southeast trending Canon City-Florence basin. The current embayment is the result of east west compressional forces during the Laramide which resulted in the post-Cretaceous folding and faulting of the area (Gerhard, 1967).

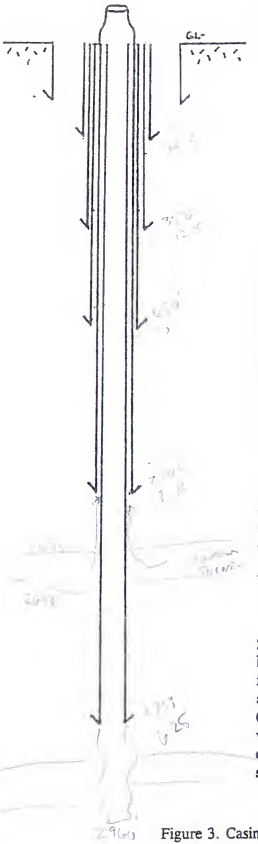
The Canon City-Florence Basin (Chandler Syncline) is an asymmetrical basin with steeply dipping sedimentary strata along its western margin and gently dipping beds on its eastern flank (figure 4). The axis of the syncline parallels the Wet Mountains, from its northern termination by the southern end of Front Range southward to its termination by a thrust of Pre-cambrian rocks onto the Cretaceous sediments and termination of the axis by the fault. The Chandler syncline is doubly plunging from both the north and south to its deepest point just south of the city of Canon City. Dips within the basin vary from a maximum of up to 45 degrees along the western flank to nearly horizontal along the basin axis and less than 10 degrees along the eastern flank.

The Fourmile Creek graben is a V-shaped structure beginning approximately 4 miles southwest of Cripple Creek and extends about 14 miles south to were the graben opens to its maximum extent of 10 miles in width. The graben is characterized by steeply dipping reverse and normal faults which bound the structure along both the east (Garden Park Thrust, Cooper Mountain Fault) and the west (Twin Mountain Fault). The southern termination of the graben is considered to be represented by a semicircle of Niobrara outcrops around the north lobe of the Canon City-Florence basin.

Hydrostratigraphic Units

The Morrison and Ralston Creek Formations are generally sequences of impermeable siltstones, claystones and shales with minor lenses of permeable beds that occur locally, and cannot be traced over long distances. The Ralston Creek Formation includes a massive gypsum section interbedded with siltstones or shales which are of low hydraulic conductivity and forms an

PARK CENTER WELL
COMPLETION DIAGRAM



Casing Record

28" wooden conductor casing set at 25'

15.5"- 52# National casing set at 100'

12.5 "- 52# National casing set at 350'

10" - 40# National casing set at 650'

8.25"- 32# Jones L casing set at 2201'

6.25"- 24# National casing set at 2738'

The well was originally completed with the placement of 4.75" pipe to a total depth of 2819 ft. All of the 4.75" pipe was recovered from the well in 1933 with the exception of the shoe and 1 or 2 joints. The 6.25" casing was stretched but could not be recovered as it was frozen (stuck) somewhere below the 8.25' casing at 2201 ft. All other casing remains in the well with the exception of the conductor which was removed by decay.

Cementing Record

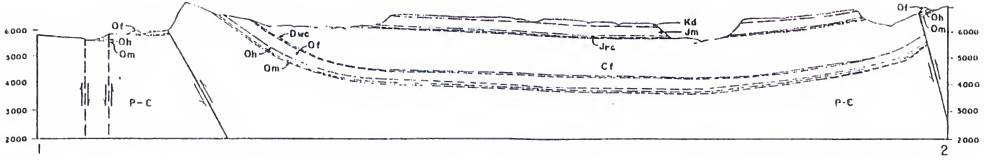
The well was drilled during the period April 1923 to 1927. The total depth (TD) of the well was 3216 feet (+2319'). The well was plugged back with cement to approximately 2960 ft. (+2675'). None of the casing placed in the well was cemented.

Water Production

Water sources are estimated to be situated at 2675'-2698' (500 bbls/hr) and at 2778'-2797' (1143+ bbls/hr.). The water production from the upper zone is delivered via the annular space between the 8.25" and 6.25" casing. The lower zone is delivered via the 6.25" casing. The production is reduced at the surface via a swedge nipple which is attached to the 8.25" casing and then reduced to 6" where it attaches to the surface piping system.

Figure 3. Casing and completion record of the Park Center Well.

STRUCTURAL CROSS-SECTION
NORTHERN PORTION
CANON CITY EMBAYMENT



CRETACEOUS	Kd	DAKOTA SS & PURGATOIRE
JURASSIC	Jm	MORRISON
JURASSIC	Jrc	RALSTON CREEK
PENNSYLVANIAN	Cf	FOUNTAIN
DEVONIAN	Dwc	WILLIAMS CANYON
ORDOVICIAN	Of	FREMONT LIMESTONE
ORDOVICIAN	Oh	HARDING SANDSTONE
ORDOVICIAN	Om	MANITOU LIMESTONE
PRE-CAMBRIAN	PC	IGNEOUS & METAMORPHIC

Figure 4

Adapted from: Schulze, 1954.

aquiclude throughout most of the formation thickness and is the confining unit over the Fountain Formation. The impermeable siltstone and claystone beds in the Morrison Formation form a tight stratigraphic trap in which oil and gas shows are contained, and small quantities of poor quality (saline) water. Both of these units form an aquiclude overlying the Fountain Formation. The Fountain Formation itself contains beds of siltstone, conglomerate and micaceous shale (Howard, 1966, Gerhard, 1967) and is characterized by rapid lateral and vertical facies changes having wide ranges of values of hydraulic conductivity. These units are low permeability facies within the Fountain Formation that overlie beds of homogeneous sandstone that are saturated, forming the producing zone at intervals 2675-2738 ft. and 2778-2797 ft. depth.

According to the driller's log of the Mutual Oil Development Co. Well (Park Center Well), small quantities of poor quality water occur in thin permeable beds in the lower Morrison Formation at about 500 ft. depth, and in the Fountain Formation at about 1250 ft. An oil show was found in the Morrison at 245 ft. depth; oil and gas shows were found at several deep intervals in the Fountain Formation down to about 2,000 feet depth. A high rate of water flow under artesian pressure was found in the lower Fountain Formation at about 2680 feet depth. The potentiometric surface (as indicated by the shut-in pressure) of the water in the Fountain Formation was at 358 feet above land surface when the well was drilled. The artesian pressure has not declined appreciably since the well was drilled in 1925.

Ground Water Flow System

Ground water in the area of the Park Center Well occurs in two flow systems, a shallow system and a deep system. The shallow flow system includes an unconfined aquifer in alluvial deposits along Fourmile Creek, thin permeable beds within the uppermost part of the Morrison Formation at depths of perhaps as much as 200 ft., and possibly some areas of the uppermost beds of the Fountain Formation. The deep flow system consists of confined aquifers and includes a few thin permeable beds in the lower part of the Morrison Formation and a relatively thick section of sandstone/conglomerate in the lower part of the Fountain Formation. This is the zone in which the Park Center well obtains its water; it is separate and isolated from the shallow flow system. The confined aquifer system in the Fountain Formation receives its recharge from outcrops to the north and on tilted beds along the east and west sides of the Chandler Syncline.

In the shallow flow system, the alluvial deposits along Fourmile Creek are locally saturated and are in direct hydraulic connection with streamflow in Fourmile Creek. Streamflow in Fourmile Creek may provide some limited recharge to shallow parts of the underlying Fountain Formation, but this mechanism is not established and there are no streamflow measurements available from

which accurate quantification can be made of streamflow losses to the aquifer or gains in streamflow from aquifer discharge to the stream. Because of the presence of low permeability beds throughout most of the Fountain Formation, the amount of recharge to the deep aquifer from streamflow would likely be small, if any exists at all.

Aquifers in the upper Morrison Formation are recharged by precipitation directly on the Morrison Formation or on overlying strata such as Quaternary Landslide deposits as mapped by

Wobus, et. al, (1985) and the Dakota and Purgatoire Formations. Water percolates downward through these units to an impermeable layer in the upper Morrison Formation where it forms a perched aquifer. This normally occurs within the upper 200 feet of the formation, generally above the level of Fourmile Creek; some thin aquifers may occur at or slightly below the creek level, and could locally discharge small amounts of ground water into Fourmile Creek.

The Fountain Formation is recharged in the vicinity of the well by precipitation on flat-lying outcrops north of the well and on tilted beds that outcrop to the east (about one mile away). The tilted exposures of the Fountain Formation east of the well are probably the source of most of the recharge of the deep aquifer. Some recharge also occurs in tilted beds of the Fountain west of Canon City (about 4 miles away) and migrates to the east towards the axis of the Chandler syncline, located about 1.5 miles west of the well. North of the well, extensive deposits of the unconsolidated Louviers Alluvium (Wobus, et. al, 1985) fill the valley floor and overlie the Fountain Formation. Some shallow recharge into the Fountain Formation may occur via precipitation that seeps through the surficial unconsolidated deposits north of the well into fractures in the upper part of the Fountain Formation.

Surface Water/Ground Water Interactions

Fourmile Creek, a tributary to the Arkansas River flows southward towards the Arkansas Basin and is adjacent to the Park Center Well. Based on the well log of the Mutual Oil Co. well, there is about 2650 ft. of sediments between the producing aquifer and Fourmile Creek. Because of the great thickness of impermeable to semi-permeable sediments between the river and the producing zone in the Fountain Formation, there can be no hydraulic connection between the river and the aquifer. Vertical hydraulic conductivity values of sedimentary beds can be about one tenth to one hundredth the value of horizontal conductivity values, so except for fracturing or jointing that may be present, the vertical movement of ground water will be minimal. The low hydraulic conductivity value combined with the great thickness of sediments means that pumping of the Park Center Well will not cause any depletion of Fourmile Creek.

Any effects of pumping the Park Center Well on surface water should be indicated by losses in streamflow along Fourmile Creek. A comparison of streamflow data at two USGS gages can be made for this purpose. There are two gaging stations operated by the USGS on Fourmile Creek, one at the upper end of Fourmile Creek near the town of Victor, the other at the lower end near the confluence with the Arkansas River. By comparing mean monthly flows during the winter months when base flow conditions are approximated (i.e. no snowmelt, no runoff events due to thunderstorms, and no diversions for irrigation), an estimate can be made of the stream interaction with the ground water flow system (i.e. gains or losses in streamflow). These conditions generally exist during the period from October to March. Using water year 1994 data, the mean monthly streamflow at the gage on Fourmile Creek near the confluence with the Arkansas River showed increased streamflow compared with the flow measured at the upper end of Fourmile Creek for the months of December 1993, January 1994, and February 1994. In March 1994 there was a loss of 3.6 cfs (see figure 5). These changes in streamflow occur in Fourmile Creek as it flows through Garden Park to the confluence of the Arkansas River, a distance of about 14 miles. The Park Center Well is about 5 miles above the gage at the

confluence. The increases in streamflow can likely be accounted for by contributions from Wilson Creek (about one mile downstream from the Park Center Well), from discharge to the stream from thinning alluvial deposits or from ground water discharge into Fourmile Creek in the mile before the lower gage. In the last mile before the gage, Fourmile Creek flows across the floodplain alluvium of the Arkansas River, and shallow ground water in the alluvium likely contributes to surface flow of Fourmile Creek. The loss of 3.6 cfs in March 1994 is likely mostly attributable to diversions for irrigation rather than losses to the underlying shallow aquifer. It is notable that these stream flow measurements were made during a period when the Park Center Well was being pumped at a rate equal to about 127 gal/min, or about 19 acre-ft per month.

Date	Flow at head of Fourmile Creek	Flow at confluence with Arkansas River	Gain or loss
Dec. 1993	5.66 cfs	5.83 cfs	+0.17 cfs
Jan. 1994	6.22 cfs	6.90 cfs	+0.58 cfs
Feb. 1994	6.11 cfs	5.66 cfs	+0.45 cfs
Mar. 1994	7.20 cfs	3.60 cfs	-3.6 cfs

Figure 5. Streamflow data at Fourmile Creek at head near Victor, Colorado and at confluence with Arkansas River Near Canon City, Colorado (source: Ugland, et al., 1994)

The stream flow data indicates that there is no significant loss in streamflow along Fourmile Creek and it is most likely that the streamflow is nearly constant or possibly slightly increasing through Garden Park above Park Center Well. Due to the location of stream gages on Fourmile Creek, streamflow measurements available from the USGS are inconclusive as to whether or not there is a contribution to streamflow from deep aquifers in the Garden Park area. Any streamflow loss in Fourmile Creek is minor and could be masked by gains in stream flow below Wilson Creek. The minor losses would only be sufficient to recharge shallow aquifers.

Effects of Pumping the Park Center Well

Because of the great thickness of low permeability strata between the producing zone in the lower Fountain Formation and, Fourmile Creek there is no hydrologic connection, and the stream depletion factor is zero, because pumping will not deplete any of the streamflow in Fourmile Creek.

The potentiometric surface of the deep aquifer is at about 350 ft. above land surface. Any leakage of the confining beds via fractures would thus force water to move upward. It is doubtful that upward leakage would extend 2700 ft. to the surface and contribute ground water discharge to Fourmile Creek. A visual reconnaissance of Fourmile Creek north of the well site did not indicate that streamflow was increasing. Unless pumping of the Park Center Well is increased dramatically, the potentiometric surface of the aquifer will remain above the ground

surface, maintaining an upward gradient at the elevation of Fourmile Creek. Thus, stream depletion due to induced flow from pumping the Park Center Well will not occur.

Relationship of this well to other non-tributary wells

A cursory review of well records in the area of the Park Center well identified four wells in the Arkansas River Valley (southeast of Canon City) that are designated as non-tributary. Two wells are about nine miles south of the Arkansas River near the town of Wetmore, in T. 21 S., R. 69 W. sec. 9 and are probably not a factor in the Arkansas River flow because of their distance from the river. Of greater relevance to the issue of non-tributary designation is the Higgens Artesian Well #1 located in T. 19 S., R. 69 W. sec. 1 and the Donnelly well #1, located in T. 19 S., R. 68 W. sec. 7 NE¼NW¼. These wells are located only about 2.5 miles north of the Arkansas River, west of the town of Penrose. The Higgens Artesian Well is 1875 ft. deep, and has several hundred feet of interbedded shale and sandstone overlying the producing aquifer. The Donnelly well #1 is approximately 733 ft. deep and produces 110 gallons per minute by artesian flow (possibly from the Niobrara Formation).

Because of the great depth and its location, the Park Center Well is more isolated geologically and hydrologically from the Arkansas River than either the Higgens Artesian Well #1 or the Donnelly Well #1. The thickness of impermeable and semipermeable beds that form the confining layer is greater at the Park Center Well and because of the great distance from the Arkansas River, there is little or no opportunity for pumping of the Park Center Well to directly affect flow in the Arkansas River.

Conclusions

The existing and historical pumpage at the Park Center Well is derived from a nontributary water source that is separate and isolated from surface waters. Because of the hydraulically isolated conditions of the pumped aquifer and the great depth from which water is obtained (through intervening impermeable or low permeability strata), pumping will not cause any depletion of nearby surface water courses. Other deep wells near the Arkansas River east of Canon City are designated as nontributary. The Park Center Well is completed at a greater depth than these known nontributary wells in the area. In addition, the presence of gas in the Morrison Formation and in the upper Fountain Formation indicates that the permeability of the strata is very low, and the producing aquifer at the Park Center Well is hydrologically isolated from surface water.

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DEPARTMENT OF THE INTERIOR
Bureau of Mines

MUTUAL OIL & DEVELOPMENT CO.

No. 1 Sec. 34 17S 20W.

SW¼ SW¼ 34

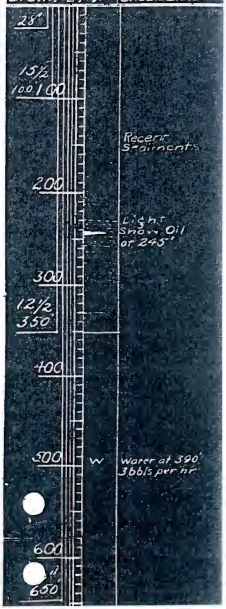
LOCATION:
766 N/S
337 W/E
DF ELEV. 6800

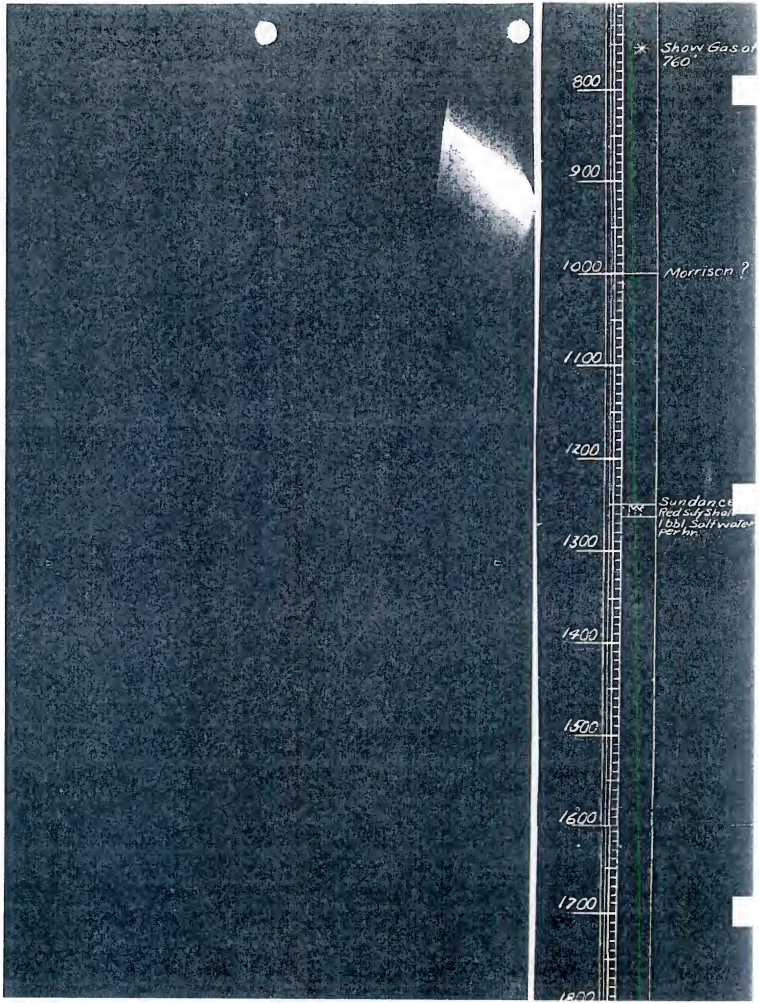
SPUDDED IN	COMPLETED
4-28-25	

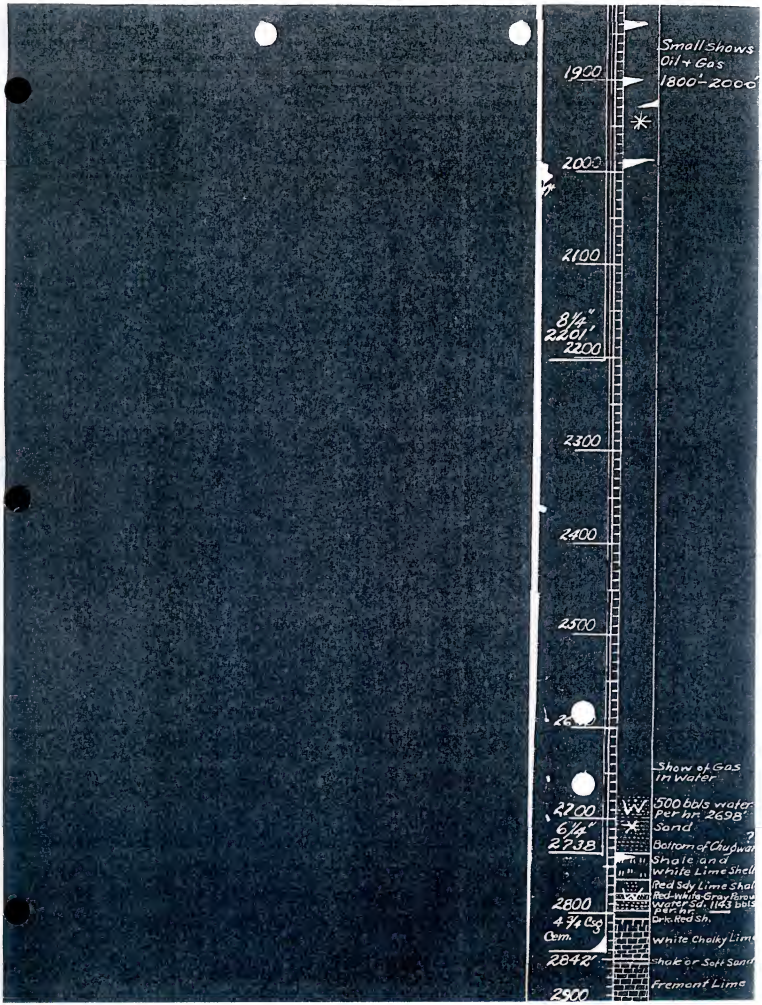
INITIAL PRODUCTION

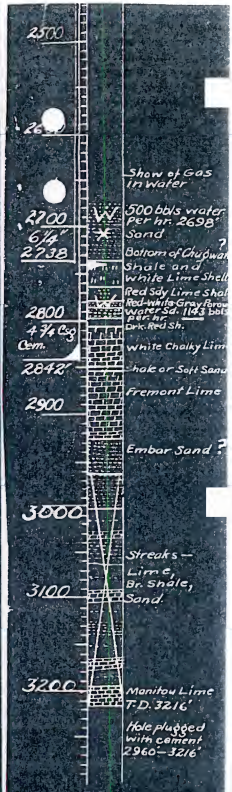
OIL	WATER BBLS	GAS
0	1143 bbls per hr.	

Drawn E.T.V. Check G.G.L.




Show Gas at 760'
800
900
1000
Morrison ?
1100
1200
Sundance
Red Soft Shale
1 bbl Salt water per hr.
1300
1400
1500
1600
1700
1800


Small Shows Oil + Gas 1800'-2000'
1900
2000
2100
8¼" 2201' 2200
2300
2400
2500
Show of Gas in Water
2200
500 bbls water per hr. 2698'
6¼" 2738
Sand
Bottom of Chuckwa
Shale and White Lime Shell
Red Sdy Lime Shal
Red-White-Gray Firew
Water Sd. 1163 bbls
2800
4½ Csg Cem.
Dark Red Sh
White Chalky Lim
2842'
Shale or Soft Sand
Fremont Lime
2900


2500
Show of Gas in Water
2700
W
500 bbls water per hr. 2698'
Sand
6¼'
2738
Bottom of Chugwat
Shale and White Lime Shell
Red Sdy Lime Shal
Red-White Gray Sand
Water Sd. 1143 bbls per hr.
2800
Blk. Red Sh.
4¾ Csg Cem.
White Chalky Lim
2842'
Shale or Soft Sand
Fremont Lime
2900
Embar Sand?
3000
Streaks — Lime, Br. Shale, Sand.
3100
3200
Manitou Lime
T.D. 3216'
Hole plugged with cement 2960–3216'